

January 11, 1960

Quarterly Progress Report No. 1  
For the period October 1 to December 31, 1959

N64 82188

## DEVELOPMENT OF HIGH ENERGY BATTERIES

SRI Project No. SU-3045

Prepared for  
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Research Contract NASw-101Introduction

The objective of this research program is to conduct studies leading toward development of a high energy battery utilizing a reactive metal anode such as sodium or lithium. Batteries are universally used for compact and reliable electrical energy sources in missiles and torpedoes. For space applications batteries can be vacuum sealed, designed to work under no-gravity conditions, and are unaffected by radiation but their present use would be increased if their size and weight could be reduced. The zinc-silver oxide primary battery most used presently has an energy output per unit weight of 80 watt hr/lb. at a potential of 1.4-1.5 volts. An improvement on such a weight specification will be attempted in this research using reactive metal anodes.

The research program can be divided into three phases: (1) study of solvent-electrolyte systems; (2) design of cell including anode fabrication, cell material selection, and cathode construction; and (3) electrical performance tests on single cells and batteries. The research conducted during this quarter centered on phase (1) and parts of phase (2).

The successful operation of a battery depends mainly on the solvent-electrolyte properties. Internal resistance, a factor of cell design and electrolyte solution conductivity, limits the power available from a battery. Low temperature operation is also dependent on the solution

conductivity, which drops when the liquid freezes. The chemical stability of reactive metal anodes, cathodes, and the resistance to attack of cell container materials are dependent on the nature of the electrolyte solution for the time of actual contact. Rapid dissolution of the anode and cathode products from the electrodes to keep the surfaces conducting and promote ionic mass transfer depend also on properties of solvent and electrolyte systems. Thus the properties of solvents and electrolytes were first to be reviewed.

### Experimental Work and Conclusions

A literature survey was conducted to find promising nonaqueous solvents for electrolyte systems. Bulk properties; dielectric constant, viscosity, freezing point, melting point, density, and reactivity; were obtained for liquids of interest which include acetaldehyde, acetonitrile, acetone, N methyl acetamide, ethylene carbonate, nitroethane, dimethyl formamide, butyrolactone, dimethyl sulfoxide, and propylene carbonate. Also, where available in the literature data on conductivity of electrolytes in these liquids were obtained.

Preliminary measurements of the conductivity of saturated solutions of salts KCl, NaCl, KBr, LiBr,  $\text{Et}_4\text{NBr}$ , and KCNS were obtained in propylene carbonate. Measurement of conductivity in saturated solutions of KCNS and  $\text{Et}_4\text{NBr}$  in dimethyl sulfoxide, acetonitrile and mixtures of N methyl acetamide with propylene carbonate have been made. Precision measurement of conductivity and viscosity on purified solvents are currently being made. Conductivity measurements are carried out with a shielded Wheatstone bridge circuit. A Hewlett Packard Model 200 C audio oscillator supplies the 1000 cps alternating current. The bridge balance point is measured visually with a Tektronix Type 531 oscilloscope.

The compatibility of liquids with lithium has been ascertained for liquids in the purity available, and certain tests are being rerun on purified solvents.

An experimental cell constructed of 1/4 inch polyethylene has been assembled for initial experiments with single cells. The cell will hold two 1/2-inch-wide lithium strips, one on each side of a 1/2 inch x 1/2 inch cathode block.

Commercially prepared solvents are available which are compatible with lithium metal and which have high conductivity with electrolytes and thus could be used in battery systems. Neither acids nor ammonium ions can be tolerated with lithium, therefore salts such as KCNS or  $\text{Et}_4\text{NBr}$  will be used as electrolytes.

### Future Work

Work on electrolytic conductors in mixed solvent - mixed electrolyte systems will be continued, and optimum systems for battery use found. Literature from The Armed Services Technical Information Agency pertinent to battery research has been ordered and the systems listed will be studied as a help in battery design. A trip to obtain information on Naval Ordnance experience in developing similar primary batteries is planned for January. Preliminary tests will be conducted on electrical properties of lithium anode cells with selected solvents-electrolyte systems and selected cathodes.

### Expenditures

A summary of expenditures for the period October 1, 1959 to December 31, 1959 is itemized as follows:

#### Total Salaries and Wages

Professional	\$ 988.36
Support	955.55
Overhead and other indirect costs	2,339.45
Expendable supplies	232.35
Major equipment	---
Travel, Comm., report preparation	2.86
Miscellaneous costs	---
Total Costs	4,518.54
Fixed Fee	357.42

### Acknowledgment

Arthur E. Reed, Laboratory Technician, carried out much of the experimental work on the program.

JEC:wh

Approved by:



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